



Philosophical Transactions

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I. *A Letter from Mr Antony Van Leewnenhoek,
F. R. S concerning Cockineel.*

Delft in Holland, March 21, 1704.

A Merchant of *Amsterdam* writ me a very obliging Letter of the 7th ult. wherein he takes notice, that he has perus'd my observations about Cockineel, and entertains me in very civil terms, that I would please to read his Remarks also, (which he has divided into seven parts) upon the same subject: I shall not rehearse them all to you, because it would take me up too much time, but only a few of the most considerable Points.

The said Gentleman affirms, that it is impossible, and altogether incredible, that the Drug call'd Cockineel should be (as I have asserted) Flies, or any sort of Animal endued with Wings, Head or Feet; not only if we consider the vast number of 'em brought in every Fleet from *America*; for you'll find that two of the biggest of these Particles, eight of the middling sort, and twenty of the smallest do hardly weigh a gold Grain, so that in a pound of 'em, at a Medium of great and small, one may count 102400 Particles; now in a Fleet that brings 200000 Pounds of this Drug, what an infinite number of Animals must there be?

Besides, says he, where can you find Men enough, who at the proper time of the year shall catch these Insects, and dismember every individual by pulling off its Head, Legs and Wings, &c. so that upon the whole matter he concludes, that Cockineel must needs be a Fruit, or the Excrecence of some kind of Plant:

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Tho I am clear in my opinion, that Cochineel is nothing else but the Trunk or hinder part of a living Creature, and was perswaded also that the Cochineel Animals, like other Insects, from Worms, are chang'd into Flies ; yet to content the above-mentioned Merchant, as well as for my own further satisfaction, I have thought fit to renew my Inquiries upon this subject ; and in so doing, I must reject some of my former Positions, being now fully convinc'd, that the Cochineel Animals are not produc'd from Worms, but at once bring forth their own Likenesses.

I have therefore, as well as I was able, made an Extract out of the Philosophical Transactions, Numb. 193. pag. 502. for the Months of *March, April, May* and *June*, where is said as follows.

Observations about the making of Cochineel, according to the Account of an old Spaniard of Jamaica, that had lived a great many years in those Parts.

IT is there said, that there is a certain Plant call'd the Prickle Pear, or *Indian Fig*; the Leaves of which are round and thick, and sharp pointed; that upon the Leaves or Twigs of the said Plant, are small Knobs or Protuberances, from whence are produced by the Heat of the Sun, little Worms, that these Worms in process of time become Flies, in likeness to Cow-ladies or Lady-birds, as some call 'em, which when they are arriv'd to their full Growth, are thus taken : To Windward of the Plant, on which these Animals are found, they kindle a Fire of any combustible matter (having first spread Cloaths under, and round about the said Plant) with the Smoak of which they are presently suffocated ; then shaking the Tree, they catch them upon those Cloaths in great numbers, and with very little trouble ; after which
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they spread them abroad in a like Cloath on a Sandy Place, or a Stone-floor, where they are expos'd to the Heat of the Sun, till they are dry'd, that is, till their small Bodies are shrivel'd up together, and rubb'd between the Hands, till their Wings, Legs, &c. fall off, which are garbl'd out, and then the remaining Trunks of the Animals are put into shallow Copper Boxes, till they become quite dry.

The abovesaid Plant has no Flowers or Blossoms on it, and the Fruit of it is of a fleshy substance and red, and when it is ripe, if you handle it, your Fingers will look as if they were stain'd with Mulberries.

Some say, that the Cochineel Worms feed upon the Blossoms and Fruit of this Plant, which causes their Bodies to be of that red colour.

And that if you take the Seed of the Plant, or the dead Worms, and dry them after the above-mentioned manner, that Cochineel is not so good as when those Animals have got Wings, and are then smother'd.

Now for my further satisfaction, I took several Particles of this same Cochineel, as well of the largest as of the smallest, and having dissected them, I found that they had all Eggs in their Bellies, save only one that was exceeding small, and there I could discover no Eggs.

When I had open'd some of the biggest Trunks, and separated the Eggs, which I took out of their Bodies, as well as I could from each other, and counted 'em also as nicely as I was able, I judg'd that there were above two hundred; and having observ'd several of them with my Microscopes, I could perceive not only a Membrane or Shell upon the most of them, but also an Animalculum of an oval Shape included in the said Shell, and almost as big as the Shell, that contain'd it; this seem'd to me at first very strange, and a Phænomenon almost incredible in so large a Species of Flies, as is the Cochineel.

I set my self then, as nicely as I was able, to discover the truth of this matter, and I labour'd the Egg-shell so long, till I was fully satisfy'd, that it was really an Animalculum that lay within it.

I pursu'd this my operation with so good success, that I did not only separate the Egg-shell from the Animalculum, but in some of them I could perceive their Legs also orderly folded up against their Body, and could separate them from it, especially in such as were full grown; yea, in some of 'em I did even discover the several Joynts of the Legs; and this good fortune I had not only in one, or ten, but in the space of two days, I saw the Legs of a hundred Animalcula, many of which, in my handling, were broken off, and lay by themselves.

One must not imagin, that these Animalcula have such short Legs as the Caterpillers or Silk-Worms, but the unborn ones have, in proportion to their b gness, as long Legs, I believe, as those that are full grown; and as the Legs of those unborn Animalcula stand close to the Head, in that part which one may call the Breast, so when the said Animalculum lay stretcht out at length, its little Legs could be just seen peeping out of the Body.

Thus are they mistaken, who give the name of Worms to these (at first) despis'd Animalcula, and the reason of their Error proceeds from hence, That thro the exceeding smallness of the object, they are not able to discover with their naked Eye, whether the new teem'd Insect be a Worm, or any other kind of Animal: As for the Eggs of these Animals, I think, I need not measure them, for they that understand Cochineel, may guess at their size when we assert that 200 or more Eggs can lye in so small a Particle of matter, as a single grain of Cochineel; to which, if you add the consideration of the great number of Blood Vessels lying in so narrow a Compass, and that each Egg receives its Nourishment and Increase (as it certainly must) by a String or Artery, yea, and that prob-

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bably there are Veins in every String for the carrying on the Circulation of the Blood, how can we sufficiently admire the Depth of Almighty Wisdom, and how unscrutable are all his Works?

I must not omit to acquaint you, that the Shape of the Eggs of the Cochineel-Fly, is very like that of our Hen-Eggs.

When I cast my Eye upon some of these Embryos, after I had devested them of the Membrane or Shell in which they were shut up, I observ'd on their Head, a kind of a Tool or Instrument, about a fifth part as long as the whole Body of the Animalculum, and at the end thereof a very slender point, something like that Instrument which Nature hath provided those Animalcula with, that are found upon Currant Bushes, &c. and by which they get their Food (according to the Descriptions I have given thereof formerly) and when they have so done, they clap it to their Breasts till they have occasion for it again.

From whence I infer that the Cochineel Flies do also acquire their Food after the same manner, to wit, that they have no Teeth whereby to gnaw the Leaves of the Plant they dwell on, as Silk-Worms do, but that they only insinuate their said Instrument into the Leaves, and after that manner get their nourishment. This notion of mine seems to be supported by what the old Spaniard said, viz. that these Animalcula feed on the Blossoms and Fruits of the Plant, and that by those means they became red.

From whence we may conclude, that the Insects don't hurt the Leaves, Fruits, nor even the Blossoms of Trees, as far as we can discover, which may also the better satisfy us, that the Cochineel Flies, with the above-mention'd Instrument, by boring into the Leaves, acquire both their Food and Increase.

I acquainted you before, that I had examin'd some of the smallest Particles of the Cochineel; my only aim was to be satisfy'd, (as I suppos'd,) that they were the Trunks or Bodies of the Male-Flie; and indeed we see, that in all small Flies, that are produced from Worms or Maggots, (at least 'tis my observation) the smallest are always the Males; and this Rule holds good also in Flies and Lice, among which also, the hinder parts of their Female Bodies are always bigger, by reason of their being so often impregnated with Eggs; but when I thought I was sure that the little ones were all Males, and had soakt their Trunks thoroughly in Water, in order to some further Inquiries, I then imagin'd, that all the Cochineel Flies are Females, and that hardly one fourth Part of 'em was arrived to their full growth, before that their Bodies are fill'd with young; but these are only Surmises that occur'd to me at that time.

This Position of mine, that all the Cochineel Flies are Females, may seem very strange, and perhaps not meet with credit by those that maintain there can be no Animal generated without a Copulation of Male and Female; but they would be of another opinion if they had seen the unspeakable number of Animalcula, which last Summer infested the Leaves of the Lime-trees, or those other that were found upon Currant Trees, Cherry Trees or Hazel-Nut Trees, all which Animalcula bring forth young alive, and these young ones being very little, have their Bodies fill'd with other young, and are all Females, and consequently there is no Copulation among them: these, when they are full grown get Wings, so that there is no other Change in them, than increasing in bulk, and the sprouting out of Wings.

Now if this be true in these above-mentioned Animalcula, altho they are fifty times smaller than the Cochineel Flies, we may easily believe the same of these also, especially since the hinder parts of all of 'em are

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much alike; in confirmation of which we may add, that Eels, Prawns or Shrimps have also no Males among them.

You may remember, the old Spaniard said moreover, that when the Cochineel Flies are dry, they rub them between their Hands, and so the Wings, &c. are separated from the remaining Trunk; but if he had been more exact in his observations, he might have found, that not only the Wings were thus separated from the hinder part of the Body, but also the upper part, with which goes also the Legs, the Wings and the Head.

And if one observes the lower part or Belly of these Animalcula, one may perceive that it is divided from the upper, by nothing but a kind of a short string, no thicker than a Hogs Bristle, so that one part may be easily separated from the other, especially when the Animalcula are dried: Now this upper and lower part of the Body are plac'd so near each other, that they will easily appear to the naked Eye to have been always united.

Furthermore the old Spaniard affirms, that the Cochineel is not so good till the Animalcula have got Wings; from whence we might be apt to conclude, that the Cochineel Animalcula do become Flying Creatures all together, just as it happens to Silk Worms, which from Reptiles, are all changed, and that in a very short time, into Butterflies.

But the Case is quite otherwise with these Cochineel Flies; (at least as far as it appears to us) for they dont lay their Eggs all together, or in one day; but I rather suppose, that one of these Animalcula at one time brings forth twenty Eggs or young ones, and so they require above ten days before they can be deliver'd of all their Eggs, for after I had taken 200 Eggs out of some of the Cochineel Flies, I saw exceeding small ones still remaining in the Ovarium or Egg-nest

In my observations upon the Lime trees, I saw not only several Animalcula that had Wings, but divers others much smaller, and that in a gradual Descent, so far that many of 'em were hatcht that very day; and these observations I did not make at one certain season of the year, but found that they continued to hatch, as long as the days were moderately warm.

And so I reckon it is with that Animalculum likewise, whose Trunk or lower parts compose what we call Cochineel; at least it was my opinion, after I had sufficiently observ'd several Grains of Cochineel given me by three different persons; for when I oppos'd some of the largest grains of Cochineel against the smallest, so far as I was able to distinguish by my Glasses, I found that 15 of the small ones were hardly equal to one of the great; and when I viewed the Powder or Dust of the Cochineel, which I took out of the bottom of a Box, I met with some Trunks of those Flies so very small, that I judg'd 100 of them unequal to one large Grain.

Since there is not one man in a thousand, that has any knowledge of Cochineel, nor of the size of its Grains, I have thought fit to cause one of them to be design'd by my Limner, see Fig. 1. A B.

I took another Grain of Cochineel, and placed it before a Microscope, and caus'd it to be drawn just as it appeared to the Limner, as you may see in Fig. 2. C D E F G. the extream Parts being describ'd by C, and by E F, a seeming Orifice, which is the Part where the String was broken off, and by which both parts of the Body were joyn'd together.

The Concave Bows or Circles that appear in the Cochineel grain D E F G, are not natural but adventitious to the said Grain, and proceeds only from the drying or shrivelling up of the great number of Eggs that lye within the Animalculum; for if the said Grain were well soakt and plump't up with Water, those concave parts would
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become convex, and be also more obvious to sight as well as the Stem of that String we just now mention'd.

But if you take one of the largest Grains, and which is somewhat flat, that part of the Trunk will not shrink inwards, the reason whereof I imagin to be, That the Animalculum, before it was kill'd, had discharg'd most of its Eggs.

I caus'd some of these Cochineel grains to be steep in Rain Water about 24 hours, and then open'd 'em in the presence of the Limner, the reason of which was, that when the Eggs and the young ones in 'em were dry, they were so shrivel'd, as I took 'em out, that it was impossible for him to discover or represent their Figure.

Fig. 3. H I K. shews you an Egg with its Shell or Membrane, as it was taken out of a grain of Cochineel, in which Egg one might see the young one within, and the Shell surrounding it.

This Egg was drawn by the same Microscope, as Fig. 2. and when we lookt upon it so long till the Egg became dry, the Shell or Membrane would become so shrivel'd, that we could no longer have a distinct view of it.

Fig. 4. L M N. represents an unborn Cochineel Animalculum, which I had separated [from the Egg-shell with a great deal of pains; the Animalculum lay with its Back to my sight, and in such a posture as to show three of its Legs.

By Fig. 5. O P Q R S. is shown a small Particle of the Vessels belonging to an Ovarium or Egg-Nest, where one may see divers broken Filaments or Strings, to which Strings the Eggs were fastned, except the great Vessel described by R. and through which I may imagin, several other Vessels received their matter for the Nourishment and Increase of their Eggs.

S T. Shows a String to which the Egg T V was fastned, as other Eggs were to the other Strings before I broke 'em off.

These Strings O P Q R S. were almost transparent, and I could see other small Particles in 'em, when I took them out of the Cochineel grain, and separated the Eggs from them; but as they begun to dry, they assumed a reddish Hew; and when they were quite dry, they became of a light red Colour.

Fig. 6. W X Y Z. represents another Animalculum, which I also took out of its Egg-shell, and gave it presently to the Limner to draw; in it are the Legs to be seen very plainly between W and X, but I could not see that Leg which lies upon the Body.

Fig. 7. A B C D. is another Animalculum clear'd of the Egg-shell, in which you may also perceive the Legs between A and B.

Fig. 8. E F G H I. describes an Animalculum lying upon a Glafs, as I had taken it two days before out of a Cochineel grain; it was not much alter'd by growing dry; it had but two Legs left, the other being broken off.

In this Animalculum appear'd, at the extremity of the Head, that crooked part described by G H. which I suppose to be the Instrument wherewith it gets its Nourishment out of the Leaves of the above mention'd Plant.

After this I took another Animalculum with some of the Blood-Vessels, out of the Belly of its Dam, which said Animalculum was also partly cover'd with the said Blood-Vessels, and placed it before my Glafs.

Fig. 9. K L M. represents a small part of the Blood-Vessels, and N O P. the Animalculum with its six Legs, as far as it could be seen.

Moreover, I saw among the Eggs that I had separated from the Ovarium, (as also fastned to the Vessels of the Ova-

Ovarium) so exceeding small Eggs, that a hundred of 'em were not equal in bigness to one great Egg, and charged my Limner to make a Draught of some of those Eggs when he was viewing the Ovarium, but he neglected to do it.

In all the Cochineel grains that ever I examin'd, I found Eggs in their Bellies, and young ones in those Eggs, but in some of 'em many more than in others; and in those whose Bellies are mightily shrivel'd, I found but few Eggs; from whence I concluded that such as had but few Eggs in 'em, had already brought forth a great many young, and would not have lived long, according to the Age of all small Flies that die soon after laying their Eggs.

Now, forasmuch as those Animalcula that are found upon Lime-trees, &c. have young ones in their Bellies, even before they come to half their growth, my business was to see whether it be so also with the Cochineel Flies, wherefore I took eight of the small ones, which I judg'd did not altogether make more than one large grain, such as is described Fig. 1. by A B. and steep't them over night in Rain-Water, and next morning I found but five that had subsided, the other three being so light as to swim upon the Water which consequently had not penetrated into them.

Out of the first of these small grains that I dissected, I took eleven Eggs, in some of which the Animalcula were so compleatly form'd, that I could easily see their Legs, besides several exceeding small Eggs.

In the second I could meet with no Eggs that were come to their full growth.

Out of the third I took three perfect Eggs.

In the fourth there were none perfect.

In the fifth two perfect Eggs, but always less.

From these Observations I conclude, that the Production of the Cochineel Flies happens after the same manner

manner as that of the Animalcula upon the Lime, Currant, Plumb and Hazel-nut Trees.

As for what the old *Spaniard* said farther, that they stifle the Cochineel Flies with Smoak as soon as they have got Wings, because then the Cochineel is better ; this is not strange at all, because when the said Flies are arrived to their full growth, their Bodies are at that time most full of Eggs ; from whence in my opinion is chiefly derived that noble colour of Scarlet, notwithstanding which, I must needs affirm, that most of these Cochineel Flies (as far as I could observe) are kill'd or smother'd before they come to their full growth.

Methinks it is odd, that the *Spaniard* should not tell us whether they gather the Cochineel once or twice a year, the rather because the Islands of *Cuba*, *Hispaniola* and *Jamaica*, from whence it mostly comes, in comparison of our Countries, have little or no Winter ; for those Islands lying between 18 and 23 degrees of N. Lat. the Sun, in their Winter is 40 degrees above the Horizon, whereas with us at the same time it is but 14 degrees and a half above the Horizon.

If we had as much Summer as the aforesaid Islands, the Animalcula which we call a sort of Louse, would so greatly endamage the Currant Trees with their Filth, that there would be no eating of the Fruit, and yet, according to all appearance, the Cochineel Flies are more Prolifick than the Animalcula upon the Currant Trees.

The Cochineel Flies, in all appearance, do dwell upon the back or underside of the Leaves, which defend them from the great heat of the Sun in those parts ; and as the Smoak can't destroy all those Flies, the few that remain do multiply very much in a short time.

I had got about a Spoonful of Powder or Dust, together with some Sands out of the Cochineel Box, and found that that which appear'd to be nothing but Dust, was abundance of very small Cochineel Flies, and some of

'em so little as if they had been just hatch'd, and some of 'em gradually bigger than others; there were also other small Particles which I judg'd to be the Excrements of the Animalcula; I saw also abundance of Legs with three Joynts, and some also that had but two Joynts, and a few one Joynt only; among these Legs, some had Claws on, which were either white, or dark colour'd, or of a light red.

I saw moreover, some Particles that I could not bring home with me, which I judg'd to be the Heads of these Animalcula, and other Particles likewise of a beautiful red colour, that I fancy'd to be the upper parts of the Body; in the said Dust there were also some few pointed Instruments, or rather Prickles, that were no thicker than a single hair of ones Head, among which there were two or three that were four times as thick as the rest; and these, I presume, were the sharp Prickles, wherewith (as the *Spaniard* tells us) the Leaves were armed, because some of them were of a bright, others of a darker yellow.

Forasmuch as the said Prickles are guarded with an infinite number of Teeth like Saws, I have thought fit to take a draught of such a wonderful Product of Nature.

Fig. 10. Q R S. represents the said Prickle with abundance of Teeth about it, and no thicker than the Hair of my Head.

I was not able to discover the Legs of those Animalcula, which I told you I took out of the aforementioned Eggs, unless I had put them out of that exact Order in which they lay, neither could I see them in their natural disposition, tho I took a great deal of pains to do it; the reason of which is, that the Animalcula, whilst they were in the Egg, were of a dark red colour, and not at all transparent, especially such as were almost come to their full growth; at last, but with great difficulty, I could perceive, of some Animalcula that were in the Egg, six
Legs,

Legs, dispos'd in such exact order, as you may have observ'd in the Aurelia of a Silk-Worm. At the same time I discover'd that the unborn Animalcula had two Horns, in which, at one time, I counted five Joynts, and another time I thought I saw more.

After these observations of mine, to wit, that the Cochineel Animalcula are not chang'd from Worms to Flies, I reject my former Positions, consisting herein, that the Cochineel Flies have no Shields wherewith they cover their Wings, having found among the Cochineel Grains, little Shields or *Vaginae* that were black with a small round red spot upon each Shield, whereupon I and others judg'd, that these were the Shields of the Cochineel Flies.

The Animalcula, whose Wings are cover'd with Shields, are all of 'em, as far as I know, produc'd either in the Earth or in Wood, from whence they receive their Nourishment and Growth; and if Nature had not made this Provision for them, being shut up in the Earth or Wood after that they are chang'd into flying Creatures, they could not dig out their way without hurting their tender Wings.

For having found amongst the Cochineel grain, one of the aforesaid Shields upon the hinder part of an Animalculum, and viewed the same more narrowly, I saw plainly, that that Trunk or hinder part had no Similitude with any of the other Cochineel grains.

Now seeing that all Creatures from the beginning are made to bring forth their like, if the Cochineel Flies had been endow'd with Wings, it would have been in vain for the reasons above-mention'd, indeed it is necessary they should have Wings as soon as they are full grown.

I sent my *Amsterdam* Friend a Duplicat of what I have here related to you at length, as well as a Copy of the inclosed Figures, who has return'd me a long Letter in answer thereto, wherein he says, that he has also taken 200 Particles out of a large Cochineel Grain, but that he

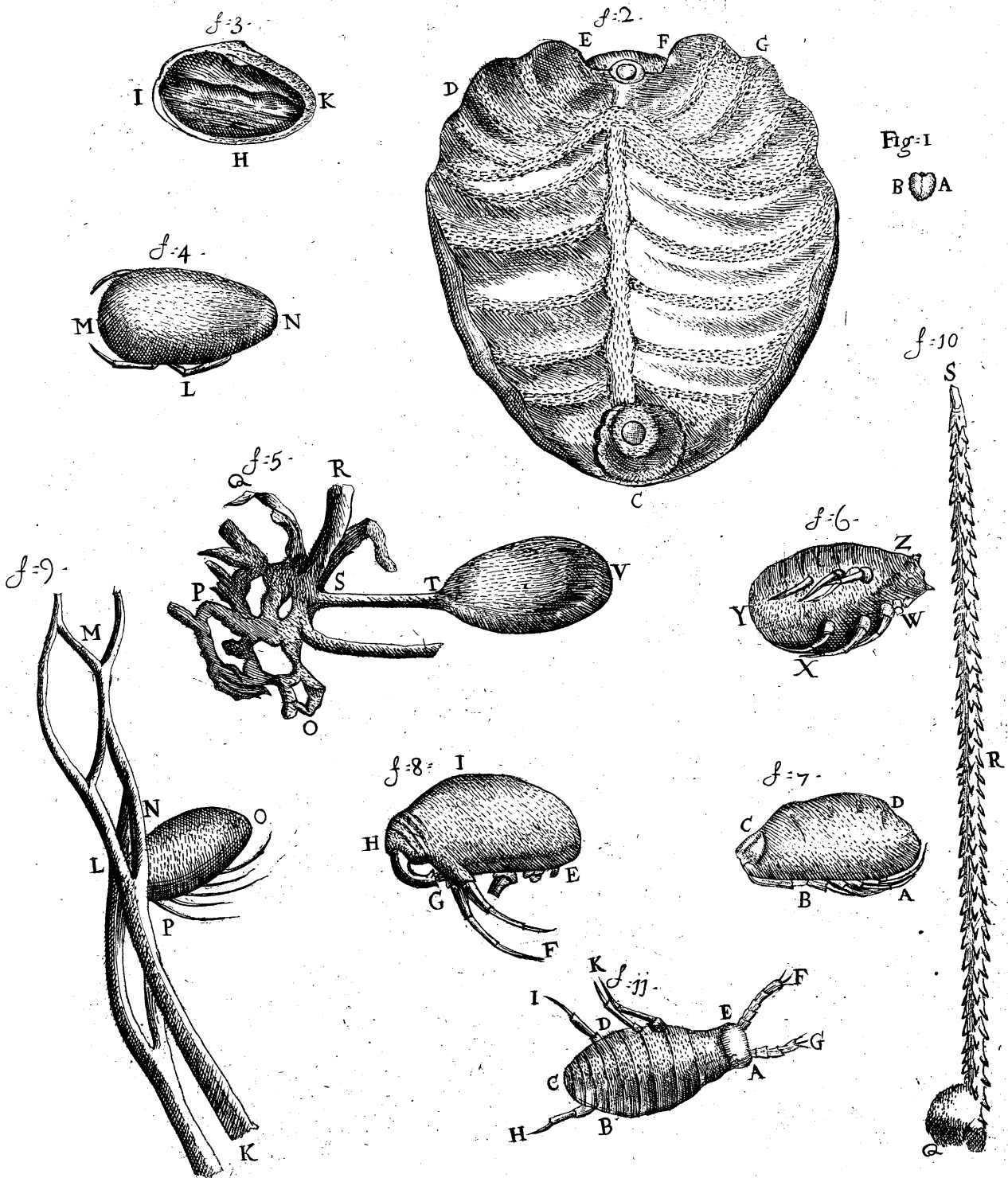
could not after the nicest observations, discover any Animalcula in the Eggs, &c. wherefore he finally concludes, that what I call Blood-Vessels are analagous to the same parts which we find in Cherries, Grapes, &c. and that what I take for the Shell or Membrane of the Egg, are only the Skins that cover the Seed.

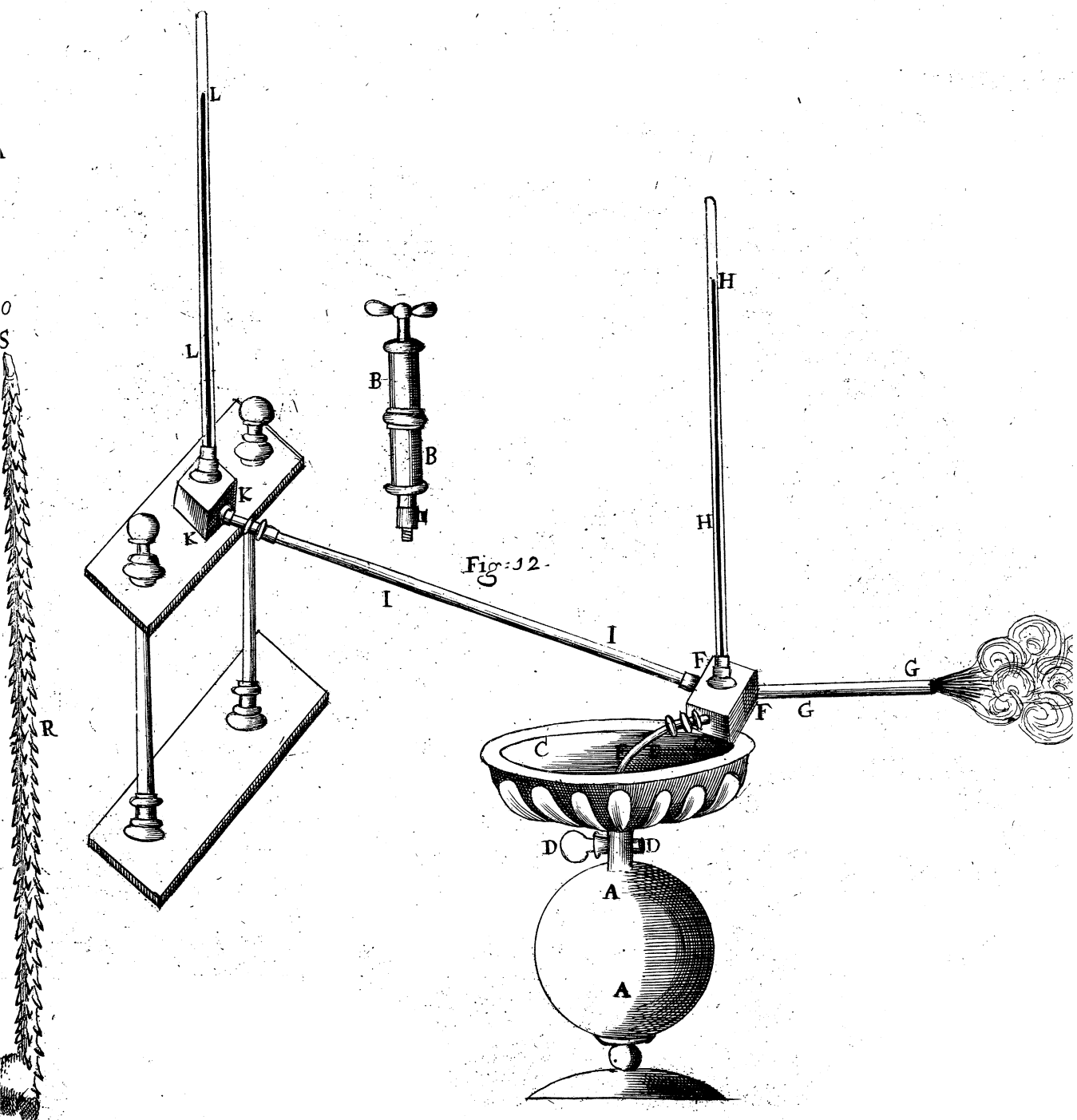
Now, tho I was entirely satisfy'd, as to my own particular, in the account I have given, and Draughts I have caus'd to be taken of the Cochineel grain, yet I dissected several others of the largest sort, and took the Animalcula out of the Egg-shell, and placed them before divers glasses in such order, that I could not only distinctly see the body of the Animalculum, with its parts divided into several Circles, but the two Horns also, with the Joynts wherewith Nature has provided all these unborn Animalcula, were as plainly visible; and the next day I caus'd the Limner to take a draught of such an Animalculum, just as it appear'd to his Eye, without adding or diminishing any thing from it, which is my manner at all times.

Fig. 11. A B C D E. shows the Body of the said Animalculum, B H. D I. and D K the 4 Legs, the 2 other being hid from the sight: E F represents one of the Horns, of which we had a very fair view, the second Horn A G. was not placed in so convenient a light, and consequently not so well delineated; at the end of the Horns were three small Hairs, which are also described by F. and G.

Thus I have given you my observations, conceptions and conclusions about the Cochineel Grains or Animalcula; and if any body else shall make any farther Remarks upon this subject, and thinks that I am mistaken in any of my Discoveries or Inferences from them, I shall be obliged to 'em, if they will let me know it, and shall freely submit to the opinion of such as shall make any better Experiments upon this business of Cochineel.

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